

# RELAP5 NEWS

Sponsored by the Nuclear Regulatory Commission

Vol. 00 No. 4

Fall, 2000

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**RELAP5 News**

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RELAP5 User Community*

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## Fall 2000 TRAC-M Workshop and CAMP Meeting

*by Jennifer Uhle, USNRC*

Annapolis, Maryland was the site of the Fall 2000 CAMP Meeting, which was held on November 9 and 10. This year the CAMP Meeting was preceded by a two-day workshop, during which CAMP members had an opportunity to work with the new NRC consolidated code, currently referred to as TRAC-M. This new thermal-hydraulics code will consolidate the functionality of the TRAC-B, TRAC-P, RELAP5 and RAMONA codes.

The workshop and CAMP Meeting were held in the Conference Center at the Lord Calvert House, one of the Historic Inns of Annapolis. The Inns, which date from 1772, are located in the heart of downtown Annapolis.



Representatives from twenty countries attended the Workshop and Fall Meeting. Argentina, Belgium, Brazil, Canada, Croatia, Czech Republic, Finland, France, Germany, Hungary, Italy, Korea, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the UK and the US were represented. One of the highlights of the meeting was a social gathering for dinner at the US Naval Academy Officers Club.



To provide an opportunity for hands-on work with the consolidated code, a network of desktop PCs was set up in the conference center. Demonstrations of such features as the SNAP graphical user interface pre-processor and post-processor were interspersed with problem sessions during which participants exercised the new code. The



network allowed participants to work at their computers while the demonstration was projected for viewing by the group. I had the pleasure of demonstrating the current state of RELAP5 functionality in TRAC-M with the help of Rex Shumway (ISL) and Weidong Wang (NRC). Other code features demonstrated included the SNAP pre-processor by Terry Gitnick (ISL), SNAP post-processor by Ken Jones (APT), Exterior Communications Interface by John Mahaffy (Penn State), kinetics modeling by Tom Downar (Purdue) and the TRAC-M 3-D vessel model by Shanlai

Lu (NRC) and Birol Aktas (ISL). Also, Professors Downar and Mahaffy described the parallel processing capabilities of TRAC-M. John Mahaffy and I compared TRAC-M to RELAP5. While many CAMP members have participated in testing the SNAP pre-processor, and most have seen demonstrations at previous meetings, the workshop provided the first opportunity for members to "test drive" the new post-processor.



Participants filled out a questionnaire following the workshop to help guide NRC development activities and to determine who may be interested in testing a demo version of the consolidated code. It is anticipated that the RELAP5 functionality will be fully recovered in Fall 2001 and the consolidation effort will be completed in fiscal year 2002. For SBLOCA and transients in a PWR, RELAP5 is still the primary code used within NRC and it will continue to be supported until the user community has successfully transitioned to the consolidated code. NRC is looking for suggestions for names for the consolidated code, currently referred to as TRAC-M.

Following the workshop, I had the opportunity of reporting on the Status of USNRC T- H Code Development Activities as the first presentation at the Fall CAMP General Meeting. I began by reviewing the stages of code consolidation beginning with TRAC-P modernization and conversion to Fortran 90 to create TRAC-M, followed by

consolidation of TRAC-B functionality, inclusion of 3-D reactor kinetics and consolidation of RELAP5 functionality. The process is continuing with physical model selection and assessment using a consolidated matrix. The Automated Code Assessment Program (ACAP), being developed at Penn State University, will provide numerical ranking for the physical model selection and evaluation of the consolidated code simulation fidelity as compared to the four predecessor codes.

TRAC-M modeling advances include extension of some TRAC-B components for use with PWRs, 1-D and 3-D kinetics and hydraulic connectivity by use of the RELAP based single junction component.

An additional solver has been added to TRAC-M to reduce the run time for 3D matrices with a large number of 1D connections. Numerics improvements include a coarse grain parallel version which NRC runs on its shared memory machines. The parallel efficiency for a perfectly load balanced 600 cell problem was calculated to be 97% on 2 CPUs. The exterior communication interface provides extensibility by allowing TRAC-M to interface with simplified models and other codes, e.g. CONTAIN, REMIX, external control system.

Upgrades to the TRAC-M kinetics capability include an automatic mapping routine, online graphics and various modeling improvements. A default mapping is available, but the user can specify a different mapping using Maptab. Plots of reactivity, temperatures, fluxes, etc. can be obtained with a simplistic user specified file. Modeling improvements include 1-D kinetics, pin power reconstruction and hexagonal lattice capability. Modeling improvements are in progress for MOX specific issues. These include an increased number of energy groups and partial pin by pin capability.

During the TRAC-B consolidation, steps were taken to facilitate the consolidation of RELAP5, including adding the single junction component and co-locating heat structures with hydraulic cell centers. Additional work to allow the same connectivity as RELAP5 is proceeding.

Extensive experimental and associated model development work is also going on as part of the TRAC-M code development effort. NRC is capitalizing on advances in instrumentation to



supplement the existing data base with more realistic mechanistic data. This data will be used to develop models to correct identified deficiencies. An interfacial area transport model, developed at Purdue, has been installed in a test version of TRAC-M to demonstrate its feasibility and work is continuing to expand this model to cover all flow regimes in geometries prototypic of nuclear reactor design. Rod bundle heat transfer experiments are motivated by the need for improved model accuracy in the face of eroding calculational margins. COBRA-TF is being used at Penn State to model experimental data to determine if a droplet field is needed to accurately predict reflood phenomena. Additional programs include subcooled boiling at low pressure at UCLA and phase separation at tees at Oregon State.

Following my presentation, Glen Mortensen of ISL described recent code changes made to create RELAP5/MOD3.3Alpha, including addition of new thermodynamically consistent steam tables and modifications to better handle noncondensable gases. Additional code changes include the reset option to restart from the last restart file and a user convenient restart listing at the end of the restart file. A junction based Courant limit and void fraction change limit have been added to the time step control. The time dependent volume has also been modified to better represent a pressure boundary condition. CANDU model features provided by Korea as an in-kind contribution have been installed. Henry-Fauske has been made the default critical flow model. Versions are now available for linux and Windows/PC platforms.

Randy Tompot (ISL) reviewed the status of RELAP5 User Problems. He reported that 13 new user problems were submitted to NRC between April 1, 2000 and the end of



October 2000. To date, 9 have been resolved, 1 is in work, and 3 require a new code feature and are on hold. During the one year period since the last Fall Meeting, 36 user problems were reported. A total of 26 problems were resolved, 5 are in work and 5 are on hold. The problems reported since the Spring Meeting were summarized and the resolutions explained.

Member country status reports included:

- "Status of CAMP Activities in Korea", Young-Seok Bang (KINS, Korea)
- "CAMP Activities in Finland", Heikki Holmström (VTT, Finland)
- "Status of Activities in Slovenia", Iztok Parzer (IJS, Slovenia)
- "Status of CAMP Activities in Russia", Vladimir Proklov (RRC-Kurchatov, Russia)
- "CAMP Related Activities in Argentina", Juan Carlos Ferreri (ARN, Argentina)
- "Status of Proposed CAMP Activities in Canada", Walter Thompson (ANSL, Canada)



Technical papers of general interest included:

- "Assessment of RELAP5 and TRAC-M for UPTF Downcomer Injection Test", Young Seok Bang (KINS, Korea)

- "Application of RELAP5 for Verification Analysis of EOP for VVER- 440/213 Nuclear Power Plants", Martin Blaha (TES, Czech Republic)



- "RELAP5 Mod 3.2.x Pre/Post Processor", Wolfgang Tietsch (Westinghouse, Germany)
- "Assessment of a LOCA Event in CANDU6 Reactors while in Shutdown Cooling Operational Mode using RELAP5/Mod3.2", Lucian Coltatu (ANSL, Canada)



- "Large Break LOCA Analysis for CANDU Plant Using RELAP5/MOD3/ CANDU+", Moonkyu Hwang (KAERI, Korea)
- "Assessment of RELAP5/MOD3.2.2Gamma Against the ISB-VVER SBLOCA Experiment" Sergey Pylev (RRC-Kurchatov, Russia)
- "RELAP5/MOD3.2.2Gamma Calculations of the PMK-2 2% SBLOCA Experiment", Laszlo Pernecky (KFKI, Hungary)

At the Technical Program Committee (TPC) Meeting, the following CAMP priorities were discussed and updated:

1. Numerical Issues - full developmental assessment (DA) with the release of MOD/3.3 will address this item.
2. 3-D Vessel Hydrodynamics (TRAC-M includes this item)
3. Vertical Stratification
4. RELAP5 Modernization - Completed (bit packing is removed, data dictionaries are in place, large subroutines have been re-engineered)
5. CANDU Heat Transfer Package (Contributed by Korea, in MOD3.3Alpha)

The Spring 2001 Meeting has been tentatively scheduled for April 23-25, 2001 in Prague, Czech Republic. Radomir Rehacek of the State Office of Nuclear Safety will be the host. We look forward to seeing you in Prague.

## NRC Notes

*by Tim Lee, USNRC*

As the year end approaches we are very close to having RELAP5/MOD3.3Beta ready. We are pleased with the robustness of this code version. Hopefully, the need to restart runs that have failed on properties errors with a smaller maximum time step size will become a distant memory. The new version runs a bit slower for many problems, but the mass errors are much smaller and code failures are quite rare.

A significant number of large models have been run as a part of the level 3 developmental assessment. These consist of AP-600 plant models for various events, ROSA tests, APEX tests, Bethsy tests, PWR mid-loop operation and PUMA tests. In the past these cases have required restarting following failures on properties errors. With the new thermodynamically consistent steam tables and improved handling of noncondensables, these problems have been largely eliminated. Code robustness has proven to be very good for the extensive number of cases run to date.

The success achieved with the new steam tables has resulted in their being installed

in TRAC-M as a part of the effort to achieve RELAP5 functionality. Thermodynamic properties routines are also used by the SNAP GUI as a part of its initialization procedure. NRC is working to get the new RELAP5 properties routines into SNAP.

During the last year we have also put significant effort into resolving outstanding user problems. At least we have been able to keep the list of unresolved problems from increasing significantly, by resolving most of the new problems and by resolving some of the longer standing items. After MOD3.3 is released, resolution of user problems will become a top priority item. We expect to post patches on the web site to provide immediate availability of fixes to users, just as we are now doing with the MOD3.2.2Gamma version.

## Recent Additions to RELAP5 /MOD3.3 Alpha

*by Glen Mortensen and Doug Barber, ISL*

For some time now we have been reporting on the progress made in improving the thermodynamic properties routines in RELAP5, including the handling of noncondensables. This has indeed been the major effort over the past year. There have been however, a number of recent additions to the code which we believe you will find useful. In an earlier newsletter, we briefly mentioned the CANDU models. Those of you doing work on CANDU reactors should be appreciative of this new modeling package. But, even if you never model a CANDU plant, you may well find some of the features included in this package to be very useful.

Dr. Young Seok Bang and his colleagues from Korea have contributed this package of code

improvements, billed as the CANDU Heat Transfer Models. Actually, there is a lot more to the package than just heat transfer options. To be sure, the CANDU channel component (canchan) is an important part of the package. When the canchan component is selected, the horizontal flow regime map is modified to better model the CANDU fuel channel. The Taital and Dukler horizontal stratification criteria is replaced by the Hanna criteria used in the CATHENA code. The canchan is implemented as a new component type similar to the pipe and annulus. In fact, the input cards for a canchan component are identical to those for a pipe, except for the component name. A new heat transfer option (number 124) has been set aside specifically to model the CANDU 37 fuel bundle. The basic difference is a modified CHF correlation. Unfortunately, the correlation is proprietary to AECL, so any user wishing to access the correlation must make arrangements with AECL. The correlation is not in RELAP5, and will have to be added by the user. The RELAP5 correlation includes an option for CANDU plants, but it is not the same as the AECL model.

Also included in the package is a new pressurizer component (prizer). This component has the same input as the pipe, annulus and canchan. However, prizer is specified as the component type, and one required and two optional input numbers are included on the ccc00001 card. Pressurizers have typically been modeled as pipe components. The new prizer component allows for more user control over the heat transfer to the pressurizer spray. When the pipe component is used, the spray will reach saturation prior to entering the liquid phase. The prizer allows the user to specify liquid to saturation and vapor to saturation interfacial heat transfer coefficients. The prizer component was added to model the CANDU "degasser-condenser" which serves the same function as a pressurizer in a PWR. However, the source of spray is the highly subcooled heavy-water storage tank (rather than the cold leg) so the spray is generally not saturated when it enters the liquid phase.

Those of you who use RELAP5 for licensing LOCA calculations will appreciate the addition of the Moody critical flow model as an option (card 1 option 54). This was added as a part of the CANDU package to allow comparison to vendor calculations.

Another generally useful feature is addition of

the ANS94 decay heat standard, which adds the behavior of the Pu-241 isotope. The option is designated ANS94-4 on the 30000002 card. Natural uranium CANDU reactors produce more Pu, so its contribution to decay heat is more significant than for enriched uranium cores.

CANDU plants have also made use of digital control systems, so a new control system type, DIGITAL, has been added. With so many plants converting from analog to digital controllers, this option should also find wide use. The DIGITAL controller is basically a "sample and hold" block. The user specifies a sampling rate and a delay time. The DIGITAL component samples the input signal at the sampling rate offset by the delay time. It is possible to model a sample and hold using a combination of the current INTEGRAL, TRIPUNIT and SUM blocks. Anyone who has done this will truly appreciate the new DIGITAL component.

Since the motor valve is used to model pressure control relief valves in CANDU, the ability to separately specify the opening and closing rate of the motor valve was added as a part of the CANDU package. Users may find this feature useful for various valve modeling applications. As you can see these improvements, while motivated by CANDU specific needs, should prove useful for many other applications.

We have also added some capability to assist with debugging of the code and input decks. The reason for the time step size is now printed in the last column of the screen file for normal runs. A line is written to the file every 10 CPU seconds. When card 1 option 6 is selected, the line is printed to the screen every time step. Examples of reasons that do not cut time step are: Blank => time step was increased or stayed the same; Courant => time step equal to the Courant limit; OvrCond => over condensed the steam (partial backup). Examples of reasons that cut time step in half and repeat the step are: Vod> 10% => (reason 30) change in void fraction >10%; +voidgx => (reason 222) voidg > 1.008; MErrloc => excessive mass error in a (local) volume; lterFal => iteration failure for finding pps & ustm. A list of reasons are given in a separate document: Reasons. pdf, which is part of the code documentation.